Improved Blind Pointing of NASA's 34-m Beam-Waveguide Antennas for Millimeter Wave Operation

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ABSTRACT

NASA's Deep Space Communications Network consists of three complexes of large antennas located at Goldstone, California, Madrid, Spain, and Canberra, Australia. Each of these contains a number of 34-meter aperture plus a single 70-meter aperture, shaped dual reflector antenna, all of which were originally designed as low noise, high gain systems for operation at S and X-band (2295 MHz and 8400 MHz).

The demands of future space missions for the scientific exploration of the solar system and beyond, extending well into the new millennium, have resulted in the need for considerably improved system capability with respect to data rates and total data handling capacity, and a key element in achieving these is a system wide upgrade to Ka-band operating frequencies (32 GHz).

The requirements of telemetry, as well as radio science, which utilizes the unmodulated carrier for a variety of experiments such as profiling planetary and satellite atmospheres and gravity wave searches, demand highly accurate, all-sky antenna pointing in order to minimize signal degradation and phase distortion, and the pointing requirements at Ka-band present serious challenges for the 34-meter and 70-meter antennas.

In order to meet these challenges it will be necessary to significantly improve both the blind pointing and closed loop pointing capabilities of these antenna systems. This paper describes the improvement of the *blind pointing* accuracy of NASA's 34-meter Beam Waveguide (BWG) antennas, which form the core of the network. The Blind Pointing Task isolated the following major contributors to the residual pointing errors of these antennas:

> 1) Azimuth track level errors, 2) Azimuth encoder ring gear errors, 3) Thermal distortions of the antenna structure, 4) Mechanical hysteresis and, 5) Incomplete modeling of mirror misalignments as a function of azimuth and elevation.

Additionally, it was recognized from the start that greatly improved accuracy of the measurement of absolute pointing errors was a necessity.

The items listed above have been addressed by establishing a lookup table of azimuth track errors, redesigning the azimuth ring gear, insulating and instrumenting the antenna alidade structure with temperature sensors, redesigning the elevation encoder coupling shaft, and increasing the pointing model from 1st to 4th order.

In order to quantify and calibrate these improvements, absolute measurement accuracy of all-sky pointing errors at the arc second level has been accomplished through the use of open-loop conical scanning of the antenna beam relative to point radio sources whose RA and DEC are known at the sub-arc second level.